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ABSTRACT

By teaching about and considering the elements of visual design, communication can be effected and the needs of the reader/user more effectively met. As anecdotal interaction with children indicates, information seems to be communicated more effectively when the rhetor incorporates visual elements. To increase the ability of the reader to discriminate and understand the information presented, producers of such information need to be aware of how they present that information visually on the page. Realizing that text can also be graphic in two senses--as writing and as a visual design--is an important concept for the writer, especially the technical writer, who desires to successfully communicate. Text, though simply expressed, can be unintelligible. To create accessible documents, writers, especially technical writers, need to consider design questions, similar to the way in which the poet William Carlos Williams did. Non-visually informative text (such as a memo warning of serious design flaws in the "O" rings of the space shuttle's solid rocket boosters) can be re-written to demonstrate the "laws" of visual design. Significant information on the design problem "hidden" in the memo can be made clear using elements of visual design. Technical writers should be concerned about the intended purpose of the artifacts they create and their ultimate effects on society. (Contains 26 references, a figure of a camouflaged moth, the original memo, and the rewritten memo.) (RS)

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The Rhetoric of Page Design: Making Meaning Visible

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NCTE Presentation (Nov 17-22, 1993)
Pittsburgh, Pennsylvania

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The Rhetoric of Page Design: Making Meaning Visible

"With sight infinities are given at once; wealth is its description."
Caleb Gattegno, Toward a Visual Culture

Show Me

Recently two interactions with my two oldest children opened my eyes to a concept that I'd been thinking about for weeks: information seems to be communicated more effectively when the rhetor incorporates visual elements. The first occurred when I came home from school and found my son Ted working on a report for his second grade class. His assignment was to write about an insect. He had chosen butterflies. They've fascinated him ever since we discovered a cocoon in one of our trees in Oklahoma (the state we had just moved from four months prior), and he watched the hatching process occur. His teacher hadn't given him much in the way of guidance, but Ted was hard at work and had already finished several pages. He had decided to "write a book" and had begun by folding three sheets of yellow construction paper in half. On the inside pages, he was working on the story of the life of the butterfly, drawing pictures on the left pages and writing text to accompany the pictures on the right pages. His text described the life cycle of the butterfly. He used what he learned from watching a cocoon hatch. In addition, he had gone to the encyclopedia to learn how the butterfly gets into the cocoon in the first place (something we had already talked about). When I asked him why he put the book together as he did, he explained that he wanted to make the butterfly come to life; he needed the pictures and the words to tell the story. In his words, one without the other "wouldn't make sense, Dad."

The second occurred later that evening. After coming back from Cub Scouts with Ted, my eight-year-old daughter Brieanne asked me to help her type a report (on Louisiana, the state of her birth) for her third-grade class. Earlier in the semester I had helped her type another report using the word-processor, but she hadn't worked with it enough to internalize the procedures. So, I set up the word-processor and again showed her the basics (where the delete key was, how to move around in the text using the arrow keys, etc.). As she listened, she continually said, "I see. All I have to do is . . . ," and she would replicate what I had just showed her. I helped her draw a schematic of the keyboard, and we labeled it using language she understood. For her, to see was to know, and the schematic, a visual representation of the keyboard labeled in "user-friendly" language, made the knowledge accessible.

The concept that information needs to be clearly presented and visually accessible seems self-evident for my children. When my children looked at the picture of the camouflaged moth (figure 1), they found recognizing it wasn't easy. It difficult to determine where the moth ended and the bark began; all the information blended together. Later, after we talked about it, they told me that their inability to "see" the moth was a good thing; the moth needed to hide itself to survive. In this instance, a camouflaged moth may be a good thing. But if we think of the tree as page (not hard considering it contains the material of pages), and the moth as the key information on the page, information we need to "feed" to our readers, camouflaging isn't such a good thing. The point: when we present information, especially in technical writing, we need to understand that our presentation of that information either makes it accessible or camouflages it. Unless we are deliberately trying to break up or "interrupt" the information flow, we shouldn't allow our information to all blend together.

For both my children, learning and knowing involved visual elements. I realize that linking the concept of sight to that of understanding is not a novel idea

It is, however, a useful concept when considering how we communicate and more importantly, how we can communicate more effectively. As Geoffrey Vickers wrote, "The child cannot see until he has built up a schemata by which to discriminate objects and relations. It cannot conceptualize until it has similarly developed appropriate concepts" (qtd in Pratt 244). Vickers' comment has relevance not only for children but also for anyone who learns. To make understanding possible, we must be able to perceive some order between things.

The ability to "discriminate objects and relations" applies to all we see, to include texts. This concept is not new either. Aristotle seems to say something similar in the Rhetoric: "It has already been mentioned that liveliness is got by using the proportional type of metaphor and by being graphic (i.e. making your hearers *see* things)" (190). "Liveliness" seems to be a quality in the listener as well as a strength of the actual work of rhetoric. Giving the words "life" makes them useful and meaningful. Making things "lively" seems to reveal their meaning.[1]

When Aristotle wrote the text, he was referring to rhetoric as an oral system. Using "proportional" metaphors kept things in balance; the speaker created a type of order in the listener. By using such metaphors, the rhetor could make the listener "see" things--an essential factor in the success or failure of the presentation. For Aristotle, then, as well as for my children, "seeing"--making things visible--is an essential element for effective communication.

My discussion is based on this idea of seeing and discriminating: to increase the ability of the reader to discriminate and understand the information we present, we need to be aware of how we present that information visually on the page. I plan to discuss the concept of design and then to illustrate the significance of well- (and poorly) designed documents. My intention is to illustrate how learning to "see the text" (Bernhardt) will lead to better design of the information in the text, and how that improved design will lead to more effective communication. To do so, I

will use a document from the Report on the accident of the Space Shuttle Challenger.

Communication is social and purposeful.

Communicating in general, and writing in particular, are social acts. The Latin root (communicare--to share with) of the word reflects this desire to bridge gaps between people. We share, we pass information. There have been many studies which have formulated models to help us understand how we communicate (Richards, Kinneavy, Shannon/Weaver, Fairthorn), and why. My goal is not to discuss the process; it is to discuss how we can affect the process when we communicate using written texts.

People communicate for a reason: to share thoughts, emotions, knowledge. The reason, the purpose, is what communicators need to stay focused on. Assuming there is a purpose, we can also assume that there ought to be a strategy to help effect the purpose. An early communication theorist, Warren Weaver, discussed this idea of purpose and strategy when he described his theory of communication as a means of altering someone else's conduct,

> The effectiveness problems are concerned with the success with which the meaning conveyed to the reader leads to the desired conduct on his part. It may seem at first glance undesirably narrow to imply that the purpose of all communications is to influence the conduct of the receiver. But with my reasonably broad definition of conduct, it is clear that communication either affects conduct or is without any discernible effect at all.
>
> The problem of effectiveness involves aesthetic considerations in the case of the fine arts. In the case of speech, written or oral, it involves consideration which ranges all the way from the mechanics

> of style, through the psychological and emotional aspects of propaganda theory, to those value judgments which are necessary to give useful meaning to the words 'success' and 'desired. (qtd in Pratt 11)

For Weaver, communication is successful when it effects change in the reader's/listener's conduct. To effect such change, the communicator or rhetor must be persuasive; he must move the audience. Weaver's argument seems to be an extension of Aristotle's idea that "rhetorical study, in its strict sense, is concerned with the modes of persuasion" (22). Whether or not one is willing to equate the concept of persuasion to that of altering conduct, Weaver's point about effectiveness remains important to consider. If there is a purpose, then one must consider the audience and how one may affect the audience with one's words.

A critical question a writer should ask is: how can I accomplish my purpose? The answer involves attracting and maintaining the attention of the audience. Since messages are external stimuli, and because the audience will receive the message through a sensory channel, it makes sense to think of ways to alter the reader's sensory environment. Writing is graphic, a visual stimulus. Aristotle believed that being "graphic" was essential for producing "liveliness." He believed that being "graphic" aided communication. If we extend this concept to the production of written texts, we must consider how the words we place on the page are "graphic" and how we can make them more "lively."

When my son Ted decided to show the butterfly in its stages as well as describe it, he was visually attempting to make the life stages of the butterfly visible. In essence, he was trying to bring the butterfly to life for the reader, to make it "lively." He believed to enable understanding, to communicate what he knew (what he had seen and read) and to represent what he wanted the audience to know, he had to visually assist the reader. As a result, he allocated equal priority to both

picture and word. His book is graphic. The butterfly and its life stages are given life--the reader can "see" them. By blending word and image, and by carefully allocating space on the page, he was exhibiting a fundamental, intuitive understanding of visual design. One ought to consider, as my son Ted did, how one presents words on the page.

Realizing that text can also be graphic in two senses--it is writing and is perceived as a visual design--is an important concept for the writer, especially the technical writer, who desires to successfully communicate. Once the writer accepts the graphic quality of the page, he can consciously begin to think of writing as visually designing information much as the rhetor in Aristotle's time considered speech as something that must create a visual design. How writers present information needs to be as conscious a decision as what they present.

Accessibility--Revealing the Complex

In an introduction to one of the chapters of his book, The Psychology of Written Communication, James Hartley cites the example used by Alphonse Chapanis to illustrate how the language of the text is often, even though simply expressed, unintelligible. Chapanis watched people's reaction to a sign posted in a department store.

PLEASE

WALK UP ONE FLOOR

WALK DOWN TWO FLOORS

FOR IMPROVED ELEVATOR SERVICE

Most people interpreted this notice as meaning, "to get on the elevator they must either walk up one floor, or go down two floors"; some thought it meant if they wanted to get on the elevator, they must first walk up one floor and then down two floors. Regardless, when they actually tried, they found the same notice waiting for

them. They discovered, if they were capable of rational thought by that time, that in effect, the notice meant, Please don't use the elevator is you are only going a short distance (120).

The problem with the sign was its design. By beginning with a request, followed by two imperatives, the store's patrons felt a sense of obligation to try to comply with the request by following the instructions as best they could. The problem resulted from confusing directions. Those who read the sign interpreted the directions to mean that if they wanted to use the elevator, they first had to walk up one or down two floors. Had the sign read as follows, odds are those reading it would have understood what they were supposed to do.

WE'RE EXPERIENCING ELEVATOR PROBLEMS DUE TO OVERUSE.
PLEASE WALK RATHER THAN RIDE
IF YOU ARE ONLY GOING
UP ONE FLOOR OR DOWN TWO.

In his article, Hartley discusses the importance of textual design--both layout and readability. He and several others (Wright; Duffy; Jewett) have discovered that people rarely sit down and read a document through; they usually approach it wanting to know something in particular; they have a goal in mind. Four such goals are:

- Determine if the document has information being sought
- Determine if the document is of sufficient interest/use to be read more thoroughly
- Find information (learn about a topic, i.e. how to run a computer program)
- Use as a reminder of information needed

For most readers, especially ones in business-related or technical fields, time is almost always a factor in how one perceives and uses texts.

To be effective, technical writing must be more than well-written grammatical prose. It must be easy to read; it must be accessible, a word that means understandable, as unambiguous as possible, without an overload of jargon (although the audience should factor into this decision--sometimes jargon is appropriate). As Edward Tufte says, "the task of the designer is to give visual access to the subtle and difficult--that is--the revelation of the complex" (189).

A brief (visual) example might clarify Tufte's idea. Most students of literature have been exposed to William Carlos Williams' poem, "The Red Wheelbarrow." Few, I imagine, have considered the design problem Williams faced (consciously or subconsciously). The poem, if it were written as standard prose would read:

> So much depends upon a red wheelbarrow glazed with rain water beside the white chickens.

Few people encountering such a statement would spend much time deliberating it. They would imagine, perhaps, that the writer of such a statement was a farmer in the midst of harvest or perhaps even a drought. They would read, or scan it, and go on. Williams, I believe (and I'm trying to avoid becoming entangled in an authorial intentions argument here), wanted to show the complexity contained in this simple sentence. To do so, he faced a design problem. His solution, for those unfamiliar with the poem, was:

so much depends
upon
a red wheel
barrow
glazed with rain
water
beside the white
chickens.

By breaking up the prose into visual chunks (Tufte; Hartley; Bernhardt), and using design elements such as white space, location on the page (making use of the horizontal, vertical, and diagonal axes), and setting up what appear to be similar elements, (Tufte; Hartley; Bernhardt; Duffy; Wright; Garofalo) Williams tried to give the reader visual access to the "subtle and the difficult" to make the complexity clearer.

Williams laid his poem out on the page to give the reader access. The designer/maker (in this case, poet)/writer is responsible to the reader/user. When one puts together a document, a report for instance, one should consider the design; one should be conscious of making the text accessible to the reader.

Earlier I listed four goals for readers. Writers need to consider those goals in terms of whether or not they've been successfully met. To do so, the writer should consider the following questions:

- Does the user find the information is presented in a way that has value and meaning for him/her?
- Does the user find that the design of the report enables him/her to navigate through it with maximum efficiency and minimal frustration? (Collins)

Seeing the Text--Visual Cues

To create accessible documents, writers, especially technical writers, need to consider design questions (Perkins), similar to those Williams must have had to consider while crafting his poem. The writer/designer can influence the reader on a visual level. The writer/designer can help the reader "see the text."

Many studies have been conducted about how one can help readers "see." D. L. Jewett in the early 70s discussed the effects of spacing; L. Frase and B. J. Schwartz (working for Bell Labs) concluded that text can be meaningfully indented; J. J. Foster argued that typographic cues--such as italics, bold face, capital letters--will work to help the reader see the text; and Hartley has focused on spatial cues and their

significance. All of these writers realize the significance of visual aspects of writing to increase effectiveness, to aid the writer achieve his/her purpose or aim.

In "Seeing the Text," Stephen Bernhardt points out how writing, "especially when visually informative," encourages the writer to be exact about grouping related ideas, delineating beginnings and endings, and using cues to signal to the reader a graphic representation." He also points out that even in a "nonvisually informative expository text," the writer exhibits rhetorical control over the text using cues, but the result is that the reader must carefully follow the text.

However, as I mentioned earlier, most readers, especially those in other than academic settings, don't read per se; they *skim*. The metaphor of navigation mentioned earlier is appropriate. Navigating is managing a ship or following a planned course. This course should be laid out by the writer who leaves signs (not merely the alphanumeric ones either) for the reader to help him along. Writers who know their audience well and have a clear purpose can be more effectively lay out such a course.

Layout or planning a course involves design. In Knowledge as Design, David Perkins suggests we consider design as applicable to ideas or objects that have "a structure adapted to a purpose" (37). A document written for an audience meets this criteria. Bernhardt says to "attend to the layout of the text requires considering the text as a visual gestalt, focusing attention on the total visual impact on the readers." His statement echoes Aristotle who said, "the whole business of rhetoric being concerned with appearances , we must pay attention to the subject of delivery" (165). I'm equating delivery with presentation of information, putting emphasis on the idea that presenting can be, and often is, visual.

To codify this principle of visual gestalt, much as Aristotle codifies many principles of effective Rhetoric, Bernhardt lists four "laws":

- Equilibrium (horizontal/vertical/diagonal)

- Good continuation (print, headings, groupings, uses of blank/white space)
- Effect of emphasis: location on page and typeface
- Laws of similarity (parallel structure for example) units resembling one another will be perceived as homogenous

The goal of the writer/designer using these laws is to "call the reader's attention visually to semantically grouped information" to enhance and improve communication (73).

Attending to the "Laws" of Visual Design--An Example

You can't attend to just one of these laws. You must attend to them all. To illustrate, I'll use a NASA memorandum discussing problems with O-rings in the rocket motor. The problem which ultimately led to the catastrophic disaster of NASA mission 51-L, the destruction of the Space Shuttle Challenger, and the unfortunate death of all seven crew members.

The Presidential Commission on the Challenger Disaster (1986) concluded that "the loss of the Space Shuttle Challenger was caused by a failure in the joint between the lower segments of the right Solid Rocket Motor. The specific failure was the destruction of the seals that are intended to prevent hot gases from leaking" (40). Interestingly the engineers at NASA knew that there were problems with the seals long before the Challenger.[2] In fact, they recognized that there was a design flaw in the Solid Rocket Motor as early as 1977 (123). This design flaw was pointed out in two memos (one in January of 1978 and a second in January of 1979) that "strenuously objected to Thiokol's [the contractor for the rocket] joint seal design" (123). Both were written by Leon Ray, a Marshall (NASA) engineer involved with the Solid Rocket Motors, and signed by John Q. Miller, chief of the Solid Rocket Motor Branch of NASA. Apparently these memos never made it out of NASA to

Thiokol to be acted upon. Nor did a third memorandum, one I will use as a sample text to illustrate the principles or laws of visual rhetoric.

In February of 1979, the same engineer, Leon Ray, made two visits to the manufacturers of the seals used in the joint between the lower segments of the right Solid Rocket Motor--the joint mentioned earlier that failed catastrophically. He drafted a memo describing those visits (see figure 2). During the Commission hearings on May 2, 1986, Mr. Ray was asked about that memo. He could not recall hearing that any action had ever occurred as a result of the memo, and, in fact, the "records show that Thiokol was [never] informed of the visits, and the O-ring design was not changed" (124). I intend to examine the original memorandum and apply the laws that Bernhardt lists as essential in producing a document keeping in mind the "multiple considerations of audience and purpose" (71).

The first item one observes is that Ray's document is primarily a "non-visually informative text"(Bernhardt 67). Considering that he's writing to an audience involved in time-critical actions with national importance, I find this odd. Other than the memo following a specific format, in which Ray lists those to whom he's sending the information and a subject, his document resembles an expository essay rather than a technical document. He exercises rhetorical control through "the familiar strategies of essay composition" (67): using paragraphs and internal transition words ("however," "after"). There is a sense of an organized presentation of information, but essential information is not visually evident.

A reader performing a quick scan of his memorandum might think the document merely describes the visit. All visual cues point to the visit as the focus of the document. The subject of his memo indicates that this document merely describes the visit. The first sentence, *the purpose sentence*, claims exactly that. Each of the two other paragraphs, both rather long and involved and containing a tremendous amount of information, begin with the words, "The visit to." It's easy

to imagine how a supervisor "reading" or scanning this memorandum would see little of value here, initial it, and send it off to be filed.

Mr. Ray made no attempt to use any visual clues such as italics, boldface, different type size, white space, or the position of information on the page in order to highlight his message. In essence, the "net effect . . . is one of smooth progression from beginning to end" (68) requiring the reader to actually read it in its entirety. This design seems ill-suited to the fast-paced world of NASA or any business for that matter, and flies in the face of common sense.

Figure 3 is a rewritten version of what I think Mr. Ray's memo might have looked like had he used some of the principles of design. I tried to achieve the law of equilibrium by balancing the heading (which takes up quite a bit of the upper left hand portion of the document) with the signature block and distribution and appendix section. The main document is now centered (rather than sprawling across the entire bottom portion of one page and the top of another).

The law of good continuation is achieved by using headings (Summary, Results, Recommendations) and thus "grouping" like information. The use of white space achieved by creating lists helps visually direct the reader to the information as grouped.

I used the law of emphasis to focus on what I considered the real substance of the memo (and what the Rogers Commission implied was the substance): the fact that both manufacturers of the seal thought that it wasn't functioning as intended, a fact that the designer of the motor--Morton Thiokol--needed to know early in the development of the shuttle. To emphasize the key information, I first modified the "SUBJECT" line by making it read "Results of Visit . . ." and adding the information about the problem with the gaps created by improperly designed O-rings. I then highlighted that problem in the summary. Finally, in the results section, I used

bold-faced type to emphasize what the various manufacturers said (even though they hedged).

I applied the law of similarity by using the lists within the headings and by using parallel structure within the lists (beginning each subgroup item similarly). Using the word "Representatives" in the "Results" section and beginning each of the "Recommendations" with an active, present tense verb ("Conduct," "Provide," and "Meet").

By eliminating all the inessential details and adding them to an appendix (which would read like a record of conversation with dates, times, and names), I kept the document to one page--a critical feature for emphasis.

In creating this memo, I attempted to consider Mr. Ray's position as a subordinate. I also kept in mind his previous attempts to highlight the seal problem. Knowing his audience (the chief engineer of his branch--Mr. Eudy; the director of the Structures and Propulsion Laboratory--Mr. McCool; and the Project Managers for the Motors at Marshall--Mr. Hardy and Mr. Rice), he would more than likely have written a somewhat straightforward, factual account rather than a glorified, New York Daily News one. He would, however, have wanted to take the opportunity to highlight information that confirmed (at least partially) the data he'd already raised a red flag about twice before.

Communication--More than a Human Chain

Would this rewritten memorandum have gotten the attention it deserved? I have no way of answering that question. There were many problems contributing to the disastrous decision to launch the Challenger. Much has been written about the lack of communication and the management problems (Arnold & Massey; Bosijoly et al.; Romzek & Dubnick; Rowland; Winsor; and Dombrowski). The problems the Commission found did indeed exist. It is heartbreaking to read the

transcripts and know that some of the people in the management structure have to live with the decisions they made for the rest of their lives.

One reason for bringing Ray's memorandum to light again is to point out is that there is possibly another contributing factor to the Challenger disaster, linked to the failure to communicate, but not directly discussed in the literature about the accident thus far: the way the information was presented in print. Although much of the criticism for the Challenger disaster has focused on "failures in communication that resulted in a decision to launch 51-L based on incomplete and somehow misleading information, a conflict between engineering data and management judgment, and a NASA management structure that permitted internal flight safety problems to bypass Shuttle management" (Commission Report 92), little has been said about the memos themselves as instruments of communication.

In an extremely interesting book about the importance of visual imagery to the future of industry, medicine, education, and virtually every facet of life, Davies and Bathurst talk about how and why people communicate. They indicate through the use of a picture (figure 1) that sometimes communication is interrupted: "In the natural world, some of the most successful species have depended on the interruption of communication or its falsification (to deceive others into acting in the interest of the falsifier), like the plants that persuade insects to carry their genetic material to the right place" (2). Unfortunately, Mr. Ray's memo was like the camouflaged moth; the significant information is hidden in the middle of the memo; one could not easily "see" it. As a result, nothing occurred. No actions were taken; nobody was notified of the "results of [his] visits." The information which needed to be received and acted upon was buried in the text; seven people were buried in the ground, effectively grounding the NASA Space Shuttle program nearly seven years later.

I'm not blaming Mr. Ray. From all I've read, he seems to have acted appropriately. His attempts to notify those above him that there was a serious problem were honest attempts, taken with a concern for the mission and the possible consequences of its failure. The same can be said for the engineers at Thiokol--Boisjoly and McDonald--who continually attempted to convince the managers at Thiokol that the temperature was too low for a safe launch and the seals were suspect. In each case, communication was not effective. The attempts at persuasion failed.

My intention in highlighting Ray's memo is not to condemn or point a finger at anyone. I merely want to demonstrate that "designers should be concerned about the intended purpose of the artifacts they create and their ultimate effects on society for good or ill" (Bannon 27). I use the word "designers" as I believe Bannon does, to label anyone who is making an attempt to use a structure and adapt it to serve a purpose. Writers of documents are designers. Unfortunately few writers are consciously aware of the implications of the visual aspects of the page. They believe that writing correct prose is sufficient.

Conclusion

Early in the Rhetoric, Aristotle says, "In making a speech one must study three parts: first the means of producing persuasion; second, the style, or language, to be used; third, the proper arrangement of the various parts: (164). A document is a piece of rhetoric. It needs to be studied in as much detail as the speeches to which Aristotle refers. One must consider all elements: the method, the language, and the arrangement. Applying visual design has application to both the style and the arrangement. It also, as I implied earlier, has relevance to delivery. Written documents "should be easy to read and therefore easy to deliver [understand]" (Aristotle 176).

In conclusion, I think back to helping my daughter Brieanne. While working with her, I communicated orally, in print, and by demonstrating visually on the screen. We drew a road map for her to follow that listed the elements in steps. She listened and interacted with me, adding her own language to the drawing. In a very real sense, I built the audience into the "document"; I conducted a brief exercise in usability. The result: she learned, and in learning, she equated her ability to see with her ability to understand. Denis Dondis expresses the significance of this idea when he says, "To expand our ability to see means to expand our ability to understand a visual message and, even more crucial, to make a visual message" (7). This making requires forethought and planning. Audience and aim must be taken into account, and knowledge of how visual elements can contribute to the clarity of the delivery of information is important. By learning about and considering the elements of visual design, communication can be effected and the needs of the reader/user more effectively will be met.

Endnotes

[1] Earlier in his discussion, Aristotle makes the statement, "'God kindled our reason to be the lamp within our souls,' for both reason and light reveal things" (189). What seems to be revealed through the graphic quality of the metaphors has much to do with the rhetor's intention. The meaning seems enhanced through such a graphic device.

[2] In many of the articles cited about the Challenger disaster, and more explicitly in the President's Commission Report, the failure of the seals is discussed in great detail. Early in the history of the Space Shuttle Program, the seals were noted to be flawed in design. Several times (in 1977 and 1978/79--which I've mentioned in my discussion), engineers at NASA tried to communicate to their bosses and to the contractor, Morton Thiokol, that the seals were indeed flawed. Nothing ever came of those attempts. Much later in the program (in 1984 and 1985), the engineers at Thiokol tried to convince their managerial bosses that the seals were a potential problem. Unfortunately, by then, the Space Shuttle had launched successfully 24 times. The history of success seemed to overshadow the evidence the engineers presented expressing concern about the seals.

Plate 1. A camouflaged moth. (Reproduced by courtesy of the BBC Open University Production Centre.) See p. 2.

FIGURE 1

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National Aeronautics and
Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama
35812

NASA

Reply to Attn of: EP25 (79-23)

February 6, 1979

TO: Distribution

FROM: EP25/Mr. Ray

SUBJECT: Visit to Precision Rubber Products Corporation and Parker Seal Company

The purpose of this memorandum is to document the results of a visit to Precision Rubber Products Corporation, Lebanon, TN, by Mr. Eudy, EE5I and Mr. Ray, EP25, on February 1, 1979 and also to inform you of the visit made to Parker Seal Company, Lexington, KY on February 2, 1979 by Mr. Ray. The purpose of the visits was to present the O-ring seal manufacturers with data concerning the large O-ring extrusion gaps being experienced on the Space Shuttle Solid Rocket Motor clevis joints and to seek opinions regarding potential risks involved.

The visit on February 1, 1979, to Precision Rubber Products Corporation by Mr. Eudy and Mr. Ray was very well received. Company officials, Mr. Howard Gillette, Vice President for Technical Direction, Mr. John Hoover, Vice President for Engineering, and Mr. Gene Hale, Design Engineer attended the meeting and were presented with the SRM clevis joint seal test data by Mr. Eudy and Mr. Ray. After considerable discussion, company representatives declined to make immediate recommendations because of the need for more time to study the data. They did; however, voice concern for the design, stating that the SRM O-ring extrusion gap was larger than that covered by their experience. They also stated that more tests should be performed with the present design. Mr. Hoover promised to contact MSFC for further discussions within a few days. Mr. Gillette provided Mr. Eudy and Mr. Ray with the names of two consultants who may be able to help. We are indebted to the Precision Rubber Products Corporation for the time and effort being expended by their people in support of this problem, especially since they have no connection with the project.

The visit to the Parker Seal Company on February 2, 1979, by Mr. Ray, EP25, was also well received; Parker Seal Company supplies the O-rings used in the SRM clevis joint design. Parker representatives, Mr. Bill Collins, Vice President for Sales, Mr. W. B. Green, Manager for Technical Services, Mr. J. W. Kosty, Chief Development Engineer for R&D, Mr. D. P. Thalman, Territory Manager and Mr. Dutch Haddock, Technical Services, met with Mr. Ray, EP25, and were provided with the identical

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FIGURE 2

This Leon Ray memorandum documents his visits to two O-ring manufacturers, both of whom expressed concern relative to the O-ring performing properly in the joint design.

2

SRM clevis joint data as was presented to the Precision Rubber Products Company on February 1, 1979. Reaction to the data by Parker officials was essentially the same as that by Precision; the SRM O-ring extrusion gap is larger than they have previously experienced. They also expressed surprise that the seal had performed so well in the present application. Parker experts would make no official statements concerning reliability and potential risk factors associated with the present design; however, their first thought was that the O-ring was being asked to perform beyond its intended design and that a different type of seal should be considered. The need for additional testing of the present design was also discussed and it was agreed that tests which more closely simulate actual conditions should be done. Parker officials will study the data in more detail with other Company experts and contact MSFC for further discussions in approximately one week. Parker Seal has shown a serious interest in assisting MSFC with this problem and their efforts are very much appreciated.

William L Ray

William L. Ray
Solid Motor Branch, EP25

Distribution:
SA41/Messrs. Hardy/Rice
EE51/Mr. Eudy
EP01/Mr. McCool

page 2

FIGURE 2 (cont)

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NASA

National Aeronautics and
Space Administration

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama
35812

Reply to Attn of: EP25 (79-23)

February 6, 1979

TO: Distribution

FROM: EP25/Mr. Ray

SUBJECT: Results of Visit to Precision Rubber Products Corporation and Parker Seal Company Concerning O-ring Extrusion Gaps on Space Shuttle Rocket Clevis Joints

1. Summary. During testing of the Space Shuttle Rocket Motors, we've noted large O-ring extrusion gaps being experienced on the clevis joints. On February 1, 1979, Mr. Eudy, EE51, and Mr. Ray, EP25, visited the Precision Rubber Products Corporation, Lebanon, TN and on February 2, 1979, Mr Ray visited the Parker Seal Company, Lexington, KY. They presented the data concerning the O-ring extrusion gaps and sought opinions regarding potential risks. The visits were well received (see appendix for details).

2. Results.

a. Precision Rubber Corporation. Representatives were hesitant to make immediate recommendations, but they **expressed concern for the design saying, in effect, that the SRM O-Ring extrusion gap was larger than that covered by their experiences.** They requested time to study the data.

b. Parker Seal Company. Representatives expressed concerns similar to those of Precision Rubber Corporation. They would make no official statements concerning reliability or potential risk. **However, their first thought was that the O-ring was being asked to perform beyond its intended design, and a different type of seal should be considered.** They also requested more time to study the data.

3. Recommendations.

a. Conduct more tests with current design.

b. Provide time for further study of the data--at least one week.

c. Meet with the companies' representatives again to discuss potential risks and or alternatives.

William L. Ray
Solid Motor Branch, EP25

Distribution:
SA41/Messrs. Hardy/Rice
EE51/Mr. Eudy
EP01/Mr. McCool

Appendix A: Details of discussion

Figure 3

Dubinsky

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